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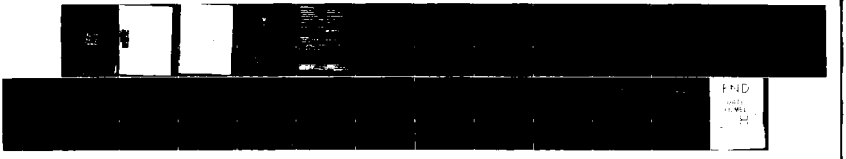

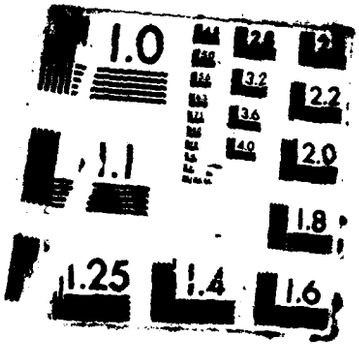
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Air combat has undergone many changes since its humble beginnings during World War I. This article examines some of the many changes that have occurred in the "dogfight" from its inception through our most recent combat experiences in Vietnam. Also included are brief glimpses at technological breakthroughs that have affected air combat as well as some of the future possibilities.

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PREFACE

Air Combat has undergone many changes since its humble beginnings during WWI. This article examines some of the many changes that have occurred in the "dogfight" from its inception through our most recent combat experiences in Vietnam. Also included are brief glimpses at technological breakthroughs that have affected Air Combat as well as some of the future possibilities. Keywords: BFM (Basic Fighter Maneuvers); avionics

Subject to clearance, this article will be submitted to TAC Attack magazine and the USAF Fighter Weapons Review for publication consideration.

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ABOUT THE AUTHOR

Major Hanson received his Bacheor's Degree in Business Administration from the University of North Dakota. After graduating from Officer Training School in April 1973, he was commissioned a Second Lieutenant. Following an initial navigator assignment, Major Hanson received his pilot wings at Williams Air Force Base, Arizona, and was assigned to fly the F-4 Phantom. As a fighter pilot, he flew the F-4D and E, the F-5A, B, E, and F models, and graduated from the USAF Adversary Tactics Instructor Course at Nellis Air Force Base, Nevada. Major Hanson's most recent assignment was as an Air Combat Instructor Pilot with the 26th Aggressor Squadron at Clark Air Base, Philippines. He holds a Master's Degree in Management and is a graduate of Squadron Officer School and the Air Command and Staff College seminar program. Major Hanson is married and has two teenage sons.

Chapter One

INTRODUCTION

"The object is to get behind the enemy and shoot him down. Anything else is rubbish."

--Baron von Richthofen, WWI

Many aviators of the recent past hold the opinion that the dogfight has remained unchanged since its early beginnings in the Baron von Richthofen days of World War I. Enthusiasts who haven't recently been involved with tactical aviation's air-to-air role still believe the Baron's assertion to be true, especially the ". . .get behind the enemy. . ." part. In almost any establishment that will serve alcohol to fighter pilots you will see these overly romantic "legends in their own minds" talking boisterously of past days' flying activities and reliving the last mission using their hands as visual aids to reconstruct the "fight." You'll hear them proclaiming that "BFM (Basic Fighter Maneuvers) haven't changed since the days of the Baron." Certainly you will hear it argued that "The dogfight itself hasn't changed either--and never will--it's as sure as fighter pilots drinking whiskey!"

The bottom line in today's air combat is still as the Baron stated in the previous quote, to ". . .shoot him down." But in the past a pilot simply needed to get behind the bandit (adversary) to shoot him because the forward firing machine gun was the only weapon available and the most efficient use of this gun was an attack from the enemy's rear. (7:24) It's not always so simple today.

In this article I will attempt to clarify what has and what has not changed in regards to the modern dogfight. First, my argument will center on the fact that BFM has and will continue to hold true throughout time. Secondly, it is my thesis that the dogfight itself will still most certainly occur, but the basic geometry of it has evolved very recently into something quite different in shape from that of Baron von Richthofen's time. Finally, I will attempt to identify what the near future holds for the modern dogfight--in terms of possibilities.

Chapter Two

HISTORICAL PERSPECTIVE

Air Combat was destiny for the flying machine as soon as the military saw an advantage in using it. Initially, the biplanes the military used were employed as "scouts" in gathering aerial reconnaissance. (1:2) Some innovative pilots even tried dropping hand-held bombs from airplanes. Nobody knows exactly who was the first to do it, but soon a bright pilot saw the advantage the opponent was gaining by utilizing aircraft and decided to deny the use of the air to his enemy by shooting him down! (6:4)

The first attempt of one pilot to shoot at another happened with hand held weapons and resembled a jousting match on horseback. (1:1) Soon, however, an enterprising individual named Roland Garros mounted forward firing machine guns on his airplane to strafe ground troops and shoot down other aircraft. (3:33) Ultimately, two adversaries both flying machine gun equipped biplanes encountered each other by chance over the skies of Europe and engaged in what is now referred to as Air Combat (ACBT). This curious spectacle of two airplanes locked in the swooping and soaring, twisting and turning of aerial sparring, each trying to get behind the other, was soon to be known as the "dogfight." (1:1)

Out of these early aerial engagements came certain principles known as Basic Fighter Maneuvers or BFM. (7:62) Much like the game of chess, the dogfight expert had a memorized set of "initial moves" and "responses" he would learn to use almost instinctively. He would try to keep these fundamentals in mind while engaging in the three-dimensional deadly ballet known as the dogfight. The principles, or BFM, were applied in different ways depending on the situation. Did our hero start the engagement offensively, on the attack, or defensively, surprised by an enemy attack? Or was it a neutral engagement, neither having the advantage? At any rate, the pilots would rely on their skill and cunning, plus their knowledge of BFM, until one of them was outmaneuvered and shot down, ran out of gas and crashed, or managed to "separate" (macho fighter pilot talk for run away!). (7:21)

All of this "jockeying for position" using BFM was necessary to arrive <u>behind</u> an adversary. Getting <u>behind</u> the adversary has always (using an absolute with reckless abandon, now!) been necessary to kill the opposing airplane (or "bandit") with a

forward firing gun. Granted, a few aircraft were downed using head-on or "snap" shots, much like an aerial strafing pass, but these were the exception rather than the rule. (7:68)

Because of the protracted maneuvering required in the dogfight, an attacking pilot can become very predictable (and vulnerable). Frequently an attacking pilot becomes so involved in the "yanking and banking" required to outmaneuver his opponent that another bandit can enter the engagement unobserved and shoot him down. (9:147) Hence the adage, "If you have a bandit in front of you, you probably have one behind you as well!" (10:50)

Just prior to the Korean War, research and development was being conducted by the militaries of both communist and free world countries to eliminate the fighter pilots' reliance on the machine gun and its mandated protracted maneuvering to kill a bandit. It was correctly reasoned that if an enemy could be killed with minimum maneuvering required, then the attacker would be less predictable and therefore less vulnerable. (10:50)

The efforts of this research soon were responsible for the invention of the air-to-air, heatseeking missile. These early missiles still had to be launched from the enemy's rear hemisphere (or "6 o'clock"), but the firing parameters (range and angles) were far less constrained than those of a tracking gun shot. Because less maneuvering was required, these missiles greatly reduced the pilot's predictability and therefore made him less vulnerable. Finally, progress was being made in shortening the time consumed in a typical dogfight. Of course, a pilot who wanted to survive still needed to know BFM, but now he had less time to use it!

Chapter Three

NEW WEAPONS TECHNOLOGY

Since weapons themselves drive tactics, we can also see that weapons technology and capability can serve to "shape" air combat itself. (1:1) Certainly it can be seen from the previous chapter that BFM and historic "rules of thumb" have stood the test of time. If a contemporary fighter pilot finds himself in an air combat situation today--he will still react in much the same way. For example, a defensive fighter will still do the time-tested "battle-break" into the opponent to either deny the tracking gunshot or defeat a missile attack. (9:155) Similarly, if he finds himself in an offensive or neutral position with respect to a bandit and he has only guns or older heatseeking missiles left for weapons, he will still employ the time tested initial moves and BFM to either kill the enemy, negate an attack, or separate.

Notice that the above paragraph has the caveat of "only guns or older heatseeking missiles" for air-to-air weapons. The reason for this caveat is obvious--the weapon's capability determines what maneuvering or tactics are necessary to either employ it or defeat it. (8:154) With this in mind I would like to discuss the advantages that some of the newer weapons offer.

As we have seen from Chapter Two, the necessity to continually maneuver behind a bandit to employ weapons often leads to a lengthy engagement. A protracted dogfight leads not only to predictability, it also slows both aircraft down which results in an energy loss. Therefore, an offensive fighter often ends up defensive in a subsequent engagement with another bandit who enters the fight.

Further research has been done in air-to-air weaponry in an effort to minimize the maneuvering required to employ ordinance. Obvious advantages in decreased predictability and increased energy sustainability are collateral benefits of this research as well. The fruits of this research effort, among other things, have been the development of greatly improved air-to-air missiles.

Shortly after the Korean conflict a major effort was put forth to create a radar guided missile. The idea was that if a missile were developed that would guide on reflected radar energy, major aircraft maneuvering could be virtually eliminated.

(2:136) Expanding further, if a fighter could detect and "illuminate" a target with on-board radar, a radar guided missile could also find and destroy the target. The advantage was obvious--you could detect and destroy a target before you even saw it--minimal maneuvering would be required. This would simultaneously reduce predictability and vulnerability.

The radar guided missile was initially developed in a crude and cumbersome manner that eventually evolved into what is now the AIM-7 Sparrow. Early versions of the radar guided missile were developed and mated to equally limited aircraft, but soon, along with the Sparrow came the F-4 Phantom jet fighter. This airplane could simultaneously carry four of the new AIM-7 Sparrow radar guided missiles and four greatly improved heatseeking AIM-9 missiles as well. (8:235) This incredible weapons load, combined with an additional crew position to operate the radar, seemed awesome.

The fighter community at that time was so convinced that the lengthy dogfight and BFM would be history that this new F-4 Phantom jet was produced without an internal gun. (8:235) Since the Vietnam conflict was in progress at this time, it served as the combat debut for this new weapon system. However, the Phantom with its eight air-to-air missiles did not do as well as expected. In fact, in 1968 the North Vietnamese managed to lose only 5 MIGS while downing 18 USAF aircraft. (8:232) Initial problems with "missing" AIM-7 shots were written off to growing pains within the system, but with the passage of time the new radar guided missiles still had not gained the confidence of the aircrews or of senior leadership. So many Sparrows either failed to fire or failed to guide (to the target) that missile employment philosophy soon became "shoot two missiles to improve the probability of a kill (P/K)." (9:152) Even with this philosophy the P/K was far less than 50%. The new version of the AIM-9 Sidewinder wasn't much better and a similar shot doctrine was employed. As a result, intentional air-to-air combat was forbidden in the Vietnam conflict from 1968 to 1972. (9:152)

The years between 1968 and 1972 were a time of soul-searching and training for the air-to-air pilots and staff trying to identify and address shortcomings in our air superiority mission. Finally, because of the poor missile performance, a 20mm gun pod was added to the F-4 Phantom. (9:153) BFM and the old familiar dogfight were again alive and well but not without penalties. The earlier euphoria over the Sparrow and the Sidewinder had led not only to the absence of an internal gun on the Phantom but also to a restricted aerodynamic design.

The Phantom was a large airplane--to carry all of those missiles! It was also designed as a high speed intercepter and as a result was not agile enough to maneuver effectively with the more nimble MIG 15s, 17s and 21s. (8:232) Engineers added an

external gun to solve the weapons reliability problem and added leading edge slats and a slotted tail to help the maneuverability problem. The resultant airplane finally managed to gain superiority over the skies of Vietnam--but just barely. Our kill ratio was a mere 2:1 at the end of the war--the lowest ratio in American air combat history. (11:22)

> You never make a big truck and tomorrow make it a race car. And you never can make a big bomber and the next day. . . a fighter. The physical law means that you need another airplane. . . . You should do one job and should do this job good. (7:330)
>
> Colonel Eric "Bubi" Hardman, GAF

The important issue here is not the kill ratio but a regression in air combat philosophy. The people who said that the Phantom and its radar guided Sparrows would make BFM and the classic dogfight obsolete had to "eat their words." The disappointment was so great that many knowledgeable aerial tacticians proclaimed that ". . .nothing had changed since the World War I dogfight except the noise, the speed, and the price of the equipment." (7:243)

Chapter Four

BETTER WEAPONS TECHNOLOGY

Our experience with air-to-air missiles in Vietnam was not a good one, to say the least. In fact, as stated in the previous chapter, our faith in the AIM-9 and the AIM-7 was very low. A pilot who managed to maneuver his jet into firing position but failed to get a kill due to missile shortcomings was not going to rely heavily on missiles in the future. As a result, the pilots had begged for guns to be installed and soon they were. (9:153) As stated earlier, we soon were back to the protracted dogfights involving excessive maneuvering because the gun required it.

We did, however, learn a lot about missiles and missile employment during the Vietnam conflict. Because of the learning that took place in the air-to-air employment of missiles, many missile kills were made. In fact, both of the American pilots who became Aces got all their kills with missiles (many missiles!). (1:42) Lieutenant Randy Cunningham, the first Ace in Vietnam, got all his kills using the heatseeking AIM-9 Sidewinder. The first Air Force Ace, Captain Steve Richie, got all of his kills with the radar guided AIM-7 Sparrow. (1:42)

With these kills as encouragement, but with the concurrent failings of hundreds of missiles, the Air Force undertook a missile improvement research and development program. (9:152) The aim of this program was to improve air intercept missiles to the point where they were easier to use from a pilot workload perspective and highly reliable as well, thus greatly increasing their overall effectiveness. The AIM-9L and M and the AIM-7F and M were the fruits of this missile research and development. (5:58)

The AIM-9L and its improved brother the AIM-9M were finally in production, though in small numbers, by 1977. (5:55) Among many improvements to the heatseeking missile, the "Lima," as it is presently affectionately referred to, boasted all aspect capability as its most sought after trait. All aspect, by definition, means that you can now shoot the missile with a high P/K (probability of kill) from any position relative to the bandit. You no longer have to maneuver behind the bandit to shoot him! If the bandit is in front of you in the vicinity of the nose of your airplane and in range, you can shoot him--no extended maneuvering ala dogfight required! (9:107)

At the same time, the radar guided AIM-7 Sparrow was improved dramatically as well. The onboard avionics were improved and miniaturized allowing for simultaneous increased reliability and a larger more powerful engine (due to room vacated by electronics). (5:61) These new versions were termed the AIM-7F and AIM-7M, with the latter being an improved AIM-7F capable of better results in adverse conditions, again negating the necessity for an extended dogfight.

Chapter Five

BETTER AIRCRAFT AND AVIONICS

The improvement to the air-to-air missiles themselves could have certainly made the old F-4 Phantom a more effective weapon system. But along with the faults in the early missiles, shortcomings in aircraft avionics themselves were recognized as a large contributor to poor missile performance. In short, many missile misses (both AIM-9 and AIM-7) were attributed to poor launch constraints (range, angles, airspeed differential, radar lock-on, etc.), in other words, "aircrew error." (4:72) Pilots had to make split-second mental calculations based on the limited data given by avionics of the time and the pilots' "estimation" of these launch constraints. As a result, many missile shots simply missed because the aircrew had not satisfied the missiles' launch criteria. In pilot jargon "they were launched out of the envelope (satisfactory parameters)." (2:18)

To eliminate these understandable human errors the research and development people again went to work, but this time the idea was to improve weapons system (missile and aircraft) avionics. The desired improvements would include more and better information to the pilot as well as avionics which were easier to operate and interpret, thus reducing the probability of error. (4:72)

Today airplanes like the ARN-101 modified F-4E, the F-14, F-15, F-16, and F-18 all have enhanced avionics that provide "shoot-cues" to the pilot. These "shoot-cues" come in various forms from aural tones heard over the aircraft's intercom to flashing lights located somewhere in the pilot's field of view. (4:74)

The bottom line to all of these avionics improvements is greater P/K of missile shots. Coupling these gains with the "super" missiles of today the contemporary fighter pilot frequently needs only to "point and shoot" at an adversary. This new capability has again greatly reduced the amount of close-in maneuvering required in today's dogfights.

Nevertheless, many of our older pilots are wary of complete dependence on the new "super" system. They remember the promises made two decades ago about the superiority of missiles, based on early tests in laboratories, and the subsequent disappointments in combat. Perhaps you've heard the postman say, "If a dog bites

me once, it's his fault. If he bites me again, it's my fault." These pilots don't want to be bitten again, so they continue to practice BFM while they preach to the younger pilots the virtues of mastering the dogfight and the gun.

Chapter Six

THE END OF AN ERA?

Missile enhancement and aircraft avionics have certainly come a long way since the Vietnam conflict. So greatly have the missiles and associated systems improved that air combat itself has finally changed. No longer is protracted BFM of yesteryear's dogfight always necessary. Today's young fighter pilots are taught primarily to point and shoot as much as possible. (12:24)

Because we can anticipate being outnumbered by enemy aircraft in many of today's probable wartime scenarios, our pilots need to avoid the previously discussed predictability that results from an extended dogfight. Certainly if you are outnumbered and resort to chasing a bandit around the sky, you will attract bandits behind you as well. "If you have a bandit in front of you, you probably have one behind you as well!" (10:50) Therefore, the correct way to handle this situation is proper use of the available weapons and avionics to kill the enemy as quickly and simply as possible with the least amount of maneuvering required. Avoid the "furball" but rather go fast, point, shoot, and separate--turning only as a last resort or when you are defensive.

Does all of this mean that the dogfight is to ever be forgotten? As a matter of fact, quite the opposite is true. Because of the possibility of limited numbers of missiles, avionics malfunctions, or political constraints, we may not always be able to fight as we want to. (5:61) So all contemporary fighters are still equipped with a gun, and all fighter pilots are still trained in the basics of BFM and the "furball" version of the dogfight.

Yes, fighter pilots still wear scarfs (though not in the cockpit!), and they still practice BFM, but modern air combat has taken on a shape of high speed airplanes traveling in relatively straight lines, pointing at and shooting the enemy, frequently before they can see him with the naked eye. Technology, it seems, has finally caught up with Brigadier General Robin Olds' vision of the future dogfight:

> I always thought to go around in circles, slower and slower, was a ridiculous thing. . . . It's not the way to fight. The best tactic is to make a pass, then break

off and come back. If you don't do this, you'll lose people; one can't be greedy. (7:25)

Chapter Seven

THE FUTURE

> Dramatic leaps in aerospace technology have occurred since the F-15--the Air Force's hottest fighter--was designed in 1969. The new generation of fighters will be faster, more agile, and harder to detect than today's warbirds. Lightweight composites, smart avionics, wings that change shape, and powerful engines will make them swift and deadly performers. (14:80)

As we have seen from the previous chapters, the shape of today's dogfight has changed. The changes are due largely to improvements in weaponry (missiles) and aircraft avionics. Who knows what the future holds?

The maneuvering capability of today's aircraft has increased tremendously at the same pace as weaponry and avionics. New breakthroughs are certainly on the horizon. With the advent of stealth technology, airplanes can now be nearly invisible to enemy radar (both airborne and ground based) with obvious effects on enemy radar missile capability. Electronic combat will also most certainly be of greater importance in the future. Missile technology is still advancing as well. We do not know exactly how the new Advanced Medium Range Air-to-Air Missile (AMRAAM) will effect air combat or if some type of high energy "laser-type" beam might even replace both guns and missiles in the future! (13:43)

Stuart F. Brown in his article, "21st Century Superfighters," envisions the following scenario in the near future:

> Cruising at supersonic speed into the night, the veteran fighter pilot is on routine patrol. Stars twinkle in the indigo sky. The heavens seem peaceful. Suddenly, the radar display on the fighter's instrument panel shows three, then seven yellow question marks approaching from the east 150 miles out. "Bad guys or good guys?" the pilot wonders, glancing at the cockpit display to confirm that his detection sensors are working properly.
>
> Then, one by one, the radar blips turn an ominous red. The fighter's fricnd-or-foe identification

circuitry has done its job. "Bogies," the machine informs the pilot in a humorless synthetic voice that sounds like it works for the telephone company. "Three of us against seven of them, with orders to engage," the pilot tells himself. "I need a plan of attack...quick."

"Virtual world," he barks into the microphone in his oxygen mask. The inside of his visor fills with a daylit color image of the night skies ahead. The seven approaching targets appear with inverted cones that depict the range of their airborne radars projecting from their noses. "They're still a few minutes away," he thinks, focusing for a moment on the time-to-intercept numbers ticking away at the edge of his vision.

Three of the oncoming targets are flying ahead of the remaining four. The pilot fixes his gaze on the nearest one. "Range?" he queries. A blinking window next to the lead aircraft shows 118 miles. "Altitude?" The display reads 37,000 feet. "Time to AMRAAM range?" he asks. Two minutes, 10 seconds, the display indicates. Then he can fire one of his medium-range air-to-air missiles. "Advisory, AMRAAM, enter," the pilot orders. The aircraft will remind him when missile-launch time has arrived.

"God's eye," the pilot commands. Immediately, like a celestial being, he is looking down from above on his area of the sky. From the God's eye view he sees his own aircraft in the middle of the scene. To the left are his two wingmen, marked in blue. Ahead are the seven red intruders, the symbolic cones of their search radars moving steadily nearer. The pilot locks his eyes on the image of the lead enemy fighter. "Target, AMRAAM," he orders, marking the enemy for his first missile shot. Transmitting over a radio link, he designates the next pair of targets for standoff shots by his wingmen. Their acknowledgments appear on the display.

"Advisory, AMRAAM," the toneless voice drones in the pilot's headphones. Now the lead targets are in missile range. The pilot reaches for the lone toggle switch on the display panel; everything else is controlled by voice or touch-sensitive overlays. He flips the master-arm switch to "on." "Weapon, select AMRAAM," he orders. "Arm AMRAAM." Then, "Fire AMRAAM." His two wingmen do likewise. Three fiery trails streak off into the night.

Cruising at 50,000 feet, with its twin turbojets running at partial throttle setting, the aircraft's speed is Mach 1.6--about 1,200 mph. The vivid green Mach number glows at the corner of his field of vision. "Let's go," snaps the wing leader. As he jams the throttles forward, the sleek gray fighter's speed increases rapidly to Mach 1.9. Afterburners wait in reserve in case a sprint up to Mach 2.5 is needed. "Status, engines?" he inquires. A symbolic representation of the twin turbines behind him appears. All the sections--inlet, compressor, combustor--are green. "Good," he thinks. "No overheating. The fire's right where it belongs." After five seconds, the image vanishes.

Then for several long moments, all three pilots are completely transfixed by their radar displays. First one, then two, then three red X's appear flashing, motionless. "That was too easy," reflects the wing leader. All the AMRAAMs have found their targets. But now lights and beepers warn that the remaining four enemies have seen the U.S. fighters on their radars. Once again, target designations are handed out.

The dogfight takes shape almost before the seven pilots know they're in it. "God's eye," the wing leader orders. "Threat priority." The aircraft's computer responds instantly. An enemy airplane turning tight four miles out at his 3 o'clock position flashes in the three-dimensional display. "Bore site," he orders. Now he's looking straight ahead.

"I'm going to get this guy," the pilot tells himself, tightening his fighter's rate of turn. As the G forces build up, the airplane's wing camber becomes more pronounced; its leading and trailing edges automatically droop to enhance maneuverability. At the same time, movable exhaust nozzles on the engines vector their awesome thrust slightly upward for a tighter turning radius.

In the driver's seat, upper- and lower-body G-suits instantly inflate with air, tightly squeezing the pilot's body to raise his blood pressure and keep him from passing out. High-pressure oxygen is forced into his constricted lungs, and the ejection seat automatically reclines several degrees as he labors to stay alert under nine times the force of gravity. The tight turn is worth it. The wider-turning enemy is in his sights. He dispatches him with a heat-seeking missile.

> Switching back to the God's eye view, his stomach tightens when he sees another enemy closing in from behind with one of his wingmen in pursuit. The airplane shudders slightly, then he briefly engages reverse thrust. His fighter buffets under the stress, and he feels as if his eyes will pop out of his head. But it works. Having scrubbed off a few hundred miles per hour of air speed, he watches enemy and wingman streak past overhead. A moment later, the wingman also scores a missile hit. Radar shows that the remaining two enemies have gone home. (14:80)

Air-to-air combat may not quite live up to the above scenario yet, but the dogfight has, out of necessity and practicality, evolved into something far different from its early beginnings in the skys of Europe. We also know that, again out of practicality and uncertainty of the future, fighter pilots still do BFM and enjoy getting into an occasional "furball" during training sorties. They still drink whiskey, tell lies, and talk with their hands when describing the day's mission, especially if it was a "furball" type of dogfight. But from a practical and survivable standpoint: ". . .for a modern fighter aircraft, the tight turn as a form of aerial combat represents the exception. . . ." (12:24)

"The dogfight complexion will change," predicts Col Albert C Piccirillo, manager of the Air Force's Advanced Tactical Fighter program. (14:82) "It won't be a sustained, spiraling fight, as it often has been. It will consist of getting weapons on target and disengaging at supersonic speeds." (14:82)

The Baron's not here anymore. The chatter of his Fokker and the fear he struck in the hearts of his enemies are only memories. But, once in a while, especially on starlit nights, his spirit flies alongside the wing of one of today's pilots and they cruise together in the darkness. The Baron's no fool. His spirit whispers a new message to the young pilot. "The object is to engage the enemy with whatever you've got and shoot him down quickly. Anything else is rubbish."

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